# Magnification and actual size

Magnification compares a measured image with the real specimen. The same relationship applies to drawings, light micrographs and electron micrographs.

## ONE RELATIONSHIP, THREE FORMS

M = magnification (no unit) • I = image size • A = actual size

$$M = \frac{I}{A}$$

$$I = M \times A$$

$$A = \frac{I}{M}$$

## 1. MATCH THE UNITS FIRST

Measure the same feature in the image and specimen. Convert image size and actual size to the same unit before dividing. Their units cancel, so magnification is a ratio, commonly written as ×400.

## 2. CONVERT LENGTH UNITS

$1\ mm = 1000\ \mu m = 10^{6}\ nm$

$1\ \mu m = 1000\ nm = 10^{-3}\ mm$

mm → μm → nm: multiply by 1000 at each step.
nm → μm → mm: divide by 1000 at each step.

## 3. DO NOT CONFUSE TWO MAGNIFICATIONS

Eyepiece × objective gives the microscope's optical magnification. A printed, resized or redrawn image may have a different magnification; use its measurements or scale bar.

Cambridge Biology 9700 syllabus: section 1.1, learning outcomes 3-4, p. 15.

# Three worked calculations

Write the relationship, convert units, substitute, then state the answer. These examples use illustrative measurements rather than a specific microscope image.

### 1. FIND MAGNIFICATION

A cell is 50 µm long. Its image is 20 mm long.

Convert: 20 mm = 20 000 µm.

$$M = \frac{20\,000\ \mu m}{50\ \mu m} = 400$$

Answer: ×400 (no unit). The image is 400 times the actual length.

### 2. FIND ACTUAL SIZE

A structure measures 36 mm on an image at ×1200.

Convert: 36 mm = 36 000 µm.

$$A = \frac{36\,000\ \mu m}{1200} = 30\ \mu m$$

Check: 30 µm × 1200 = 36 000 µm = 36 mm.

### 3. FIND IMAGE SIZE

A structure is 250 nm long. The image magnification is ×80 000.

Convert: 250 nm = 0.250 µm.

$$I = 80\,000 \times 0.250\ \mu m = 20\,000\ \mu m$$

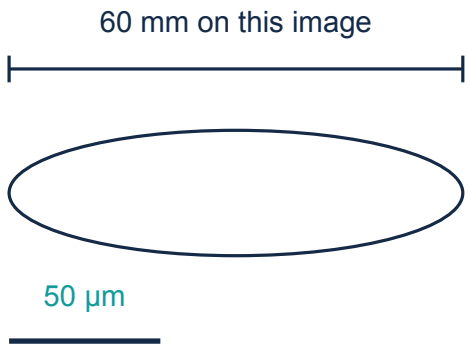
Answer: 20 000 µm = 20 mm. Image size is a length, so it needs a unit.

Relationship: Cambridge Biology 9700 syllabus, outcome 1.1.3. Examples by Jimlaoshi.

# Use a scale bar

A scale bar represents a stated real length. Compare the measured image length with the measured bar length on the same copy of the image.

### EXAMPLE: THE CELL IS THREE BAR LENGTHS LONG




The label is the real length represented by the bar.

The bar measures 20 mm on the same image.

Schematic. Resizing changes both measured lengths, not their ratio.

$$\text{Actual cell length} = \frac{60\ \text{mm}}{20\ \text{mm}} \times 50\ \mu\text{m} = 150\ \mu\text{m}$$

Use identical units for the two measured image lengths. Their ratio is 3, so the cell's actual length is 3 × 50 µm.

### 1. RESIZING DOES NOT CHANGE THE SPECIMEN

When the image and bar are resized together by the same factor, their ratio is unchanged. A stated × magnification becomes unreliable after resizing unless it is updated.

### 2. AVOID THE COMMON TRAPS

Do not treat the scale bar label as its measured paper length. Do not mix mm with µm in a division. Do not add units to magnification or leave units off a size. Measure endpoints consistently.

Final check: show your working, use sensible precision for the supplied measurements, and check that the size and unit are plausible.

Cambridge Biology 9700 syllabus: microscope measurements and scale bars, p. 53.